

CLINICAL RESEARCH

Acute appendicitis, bathrooms, and diet in Britain and Ireland

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Abstract

Hospital discharge rates after acute appendicitis were analysed in relation to the provision of household amenities and diet in 73 areas of England and Wales, nine health board areas in Scotland, and all eight health board areas of Eire. The rates of acute appendicitis correlated with the percentage of households lacking amenities, in particular fixed baths and hot water systems. Consumption of green vegetables was an additional influence on the geographical distribution of the disease.

These findings support a relation between appendicitis and hygiene, which would explain both the rise and fall of the disease during this century.

Introduction

A recent hypothesis suggested that the steep rise in acute appendicitis in Britain at the beginning of this century was the result of the public health acts in the late 1800s.¹ Improvements in hygiene consequent on improved housing, water supplies, and sanitation greatly reduced exposure of young children to enteric organisms, as shown by the fall in childhood mortality from diarrhoeal disease. It was postulated that this altered the response to subsequent infections in such a way that they caused acute appendicitis. This changed pathogenic response to infections whose frequency in early childhood was declining would be analogous to the age dependent consequences of infection with the poliomyelitis virus.

There is general agreement that the ultimate event in appendicitis is invasion of the distal appendicular wall by organisms from within the lumen. There are at least two possible mechanisms by which exogenous infections might lead to this invasion. There may be hyperplasia of the lymphoid tissue in the appendicular wall and consequent obstruction of the proximal lumen, or the ability of the

mucosa to prevent invasion may be compromised without preceding obstruction.

Having risen steeply in the first half of this century, appendicitis has declined continuously during the second half. The "hygiene" hypothesis suggests that this decline may be due to reduced exposure to exogenous infections as a result of continued improvements in hygiene. Findings in a recent study in Britain and Eire were consistent with this, showing that current rates of appendicitis were geographically related to general practice consultations for infective disease and to mortality from enteric and respiratory infections.²

None of the postulated dietary causes of appendicitis can explain the decline, which has occurred elsewhere in Europe and in North America.¹ Current epidemiological evidence points only to a relation with green vegetables. A study of 59 areas within England and Wales showed a negative correlation between rates of acute appendicitis and consumption of green vegetables.³ Extending the study to Scotland and Eire confirmed this and showed also a positive correlation with sugar consumption.²

These dietary associations may be causal or they may be secondary to associations between diet and socioeconomic influences which themselves determine enteric and respiratory infection. The main socioeconomic influence implicated by the hygiene hypothesis is the quality of housing, in particular amenities such as baths and piped hot water and overcrowding. We report an analysis of the relation between acute appendicitis and household amenities and diet in Britain and Eire.

Population and methods

Hospital Activity Analysis provided data on admissions in the county districts of England and Wales, outside London and the home counties, during 1979-82. The National Food Survey provided data on household food purchases during the same period. Each year this survey records food purchases within a sample of parliamentary constituencies.⁴ The results are expressed as average daily consumption per person in the households surveyed. By using the same criteria as in our previous study³ there were 73 areas in which county districts and constituencies were similar and appendicitis and food consumption data could be matched. Rates of acute appendicitis for these areas were calculated from the number of patients resident in them who had (a) been discharged from hospital with the diagnosis of appendicitis (ICD (8th revision) codes 540, 541), (b) been admitted as emergency cases, and (c) undergone appendicectomy (Office of Population Censuses and Surveys numbers 441, 444). Rates were directly

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standardised for age and sex by using the population of England and Wales in 1980 as the standard.

Scottish hospital inpatient statistics were used to calculate discharge rates for appendicitis in Scotland during 1979-82.⁵ In nine of the 15 health board areas one to three constituencies entirely within the area were included in the National Food Survey during these years. The Scottish data included non-acute appendicitis (ICD (8th revision) codes 542, 543), and rates of appendicitis for the nine areas were made comparable to those in the other countries by applying a correction factor of 0.86, which is the proportion of emergency admissions for acute appendicitis out of all admissions for appendicitis in England and Wales. Rates were not standardised because age and sex specific rates were not published. Hospital discharge rates for appendicitis in Scotland for 1961-3 were provided by the Scottish Health Service Common Services Agency. These were standardised for age and sex by using the same standard as for rates in England and Wales.

The Medico-Social Research Board in Dublin provided Hospital In-patient Enquiry data on discharges after appendicitis in Eire during 1979-82. Discharge rates were calculated for each of the eight health board areas by using the same criteria as for England and Wales. The rates were directly standardised for age and sex using the same standard as before. We have previously described data on food consumption within each area, which were derived from the 1980 Household Budget Survey.²

Published data from the 1961, 1971, and 1981 decennial censuses⁶⁻⁸ were used to relate data on household amenities to rates of appendicitis in the 90 areas, of which 68 were in England, five in Wales, nine in Scotland, and eight in Eire. Households without use of amenities—that is, a cold water tap, hot water system, fixed bath, and a lavatory—were defined as without either exclusive or shared use. The exceptions were in Scotland, where the 1961 census reports grouped shared use with lack of amenities, and Eire, where at all censuses these criteria were applied to baths and lavatories. The 1971 census also gave data on the percentage of households with more than 1.5 people per room. The percentage of men in social classes IV and V was available for England and Wales and for five areas in Scotland.

Results

During 1979-82, 115 064 patients resident in the 90 areas were discharged from hospital after acute appendicitis, 55 466 in England, 3521 in Wales, 28 990 in Scotland, and 27 087 in Eire. Average yearly discharge rates in the areas were 9.4/10 000 population for those in England, 11.4 in Wales, 11.7 in Scotland, and 18.1 in Eire (table I).

Table I shows the mean percentages of households in the 90 areas without amenities at the three censuses. In 1961 only 2.1% of households in the areas in England, 6.0% in Wales, and 1.4% in Scotland were without a cold water tap, whereas in Eire 42.8% were without. The figure for Eire fell sharply at the next two censuses. The distribution of lavatories was similar. Only a small proportion of households in Britain were without lavatories in 1961 compared with 46.5% in Eire, and the Eire figure fell thereafter. (The small rise in the figures in Britain from 1971 to 1981 was due to the 1981 census data relating only to lavatories inside the house.) A total of 21.7% of households in the areas in England were without fixed baths in 1961 compared with 33.0% in Wales, 26.0% in Scotland, and 74.8% in Eire. The percentages fell in all four countries at successive censuses but the ranking of the countries was maintained. In 1981, 22.1% of households in Eire remained without a fixed bath. The trend in hot water systems was similar to baths, though fewer households lacked hot water systems than lacked baths.

TABLE I—Percentage of households in 90 areas of Britain and Eire which lacked amenities at three censuses and appendicitis rates in 1979-82

Census year	Amenity	England	Wales	Scotland	Eire
1961	Cold water	2.1	6.0	1.4	42.8
	Lavatory	7.8	13.9	2.6	46.5
	Bath	21.7	33.0	26.0	74.8
	Hot water	21.1	28.5	20.6	66.5
1971	Cold water	*	*	*	21.8
	Lavatory	1.3	3.1	0.8	19.9
	Bath	8.4	12.8	11.9	52.7
	Hot water	6.0	8.5	7.1	*
1981	Cold water	*	*	*	5.1
	Lavatory	2.8	4.1	1.0	6.8
	Bath or shower	1.6	2.9	2.6	22.1
	Hot water	*	*	*	16.0
1979-82	Appendicitis rates/10 000	9.4	11.4	11.7	18.1

*Amenity not recorded at census.

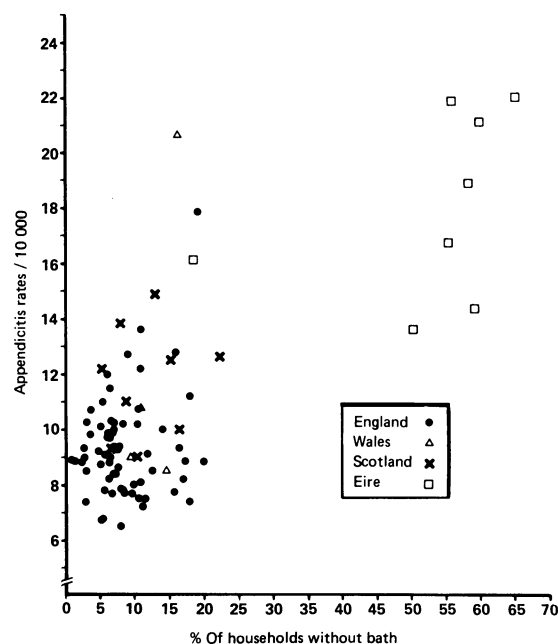


FIG 1—Percentage of households without baths and hospital discharge rates for acute appendicitis in 90 areas of Britain and Eire.

Data on baths were recorded at each census in each country, but those for the health board areas of Eire separately in 1981 were not available to us at the time of analysis. There was a high correlation between the geographical distribution of households without baths at each census, the product moment correlation coefficients being 0.97 for 1961 and 1971 and 0.98 for 1971 and 1981. The corresponding coefficients after excluding Eire, with its high percentages, were 0.92 and 0.82.

Figure 1 shows the positive correlation between the percentage of households without baths in each area at the 1971 census and rates of appendicitis. The coefficient was 0.68 ($p < 0.001$) using logarithmic values of the appendicitis rates because their distribution was skewed. When Eire was excluded the coefficient fell to 0.27 but remained significant ($p = 0.02$).

Table II shows the partial correlations after allowing for consumption of the three foods previously shown to be related to the distribution of appendicitis—that is, potatoes, vegetables other than potatoes, and sugar.² The strong positive correlations persisted, though the coefficients were somewhat reduced. Scattergrams showed that these partial correlations did not depend on only a few points—for example, those in Eire—which were at the extremes of the distributions. After allowing for all three foods by multiple regression the partial correlation coefficient was 0.34 ($p < 0.005$).

Table III shows correlations between food consumption and rates of appendicitis. Positive correlations with potatoes and sugar consumption were reduced to 0.25 and 0.24 ($p = 0.02$) after allowing for proportions of households without a bath. The negative correlation with non-potato vegetables ($r = -0.65$, $p < 0.001$; fig 2) remained significant at -0.41 ($p < 0.001$) after allowing for the proportion of households without baths.

The correlation between rates of appendicitis and the percentage of households with more than 1.5 people per room in the 1971 census was 0.68. When Eire was excluded it fell to 0.24. The percentage of households with more than 1.5 people per room was closely related to the percentage without baths, the coefficient being 0.88. The correlation between rates of appendicitis and the percentage of men in social classes IV and V, which could be calculated for Britain but not Eire, was 0.16.

Table IV shows the rates of appendicitis for the five regional hospital

TABLE II—Correlation between percentage of households without a bath in 1971 and hospital discharge rates for acute appendicitis in 1979-82 in 90 areas of England, Wales, Scotland, and Eire

% Of households without bath			Partial correlations allowing for food consumption		
Mean	Range	Correlation coefficient	Potatoes	Vegetables other than potatoes	Sugar
13	1-65	0.68	0.51	0.50	0.45

TABLE III—Correlation between food consumption and hospital discharge rates for acute appendicitis in 1979-82 in 90 areas of England, Wales, Scotland, and Eire

Food group	Consumption (g/person/day)		Correlation coefficients	Partial correlations allowing for % of households without bath
	Mean	Range		
Potatoes	183	92-299	0.56	0.25
Vegetables other than potatoes	161	96-217	-0.65	-0.41
Sugar	48	34-77	0.60	0.24

TABLE IV—Percentage of households in regional hospital boards of Scotland which lacked amenities at 1961 census and appendicitis rates in 1961-3

	Regional hospital board				
	North	North east	East	South east	West
Appendicitis rates/10 000	37.1	24.4	24.6	26.8	22.7
Cold water	14.2	4.9	1.2	0.4	0.5
Lavatory	20.3	9.9	2.6	1.0	1.0
Bath	31.7	34.4	30.5	21.2	26.4
Hot water	28.7	25.5	24.8	14.9	21.0

boards of Scotland for an earlier period around the 1961 census. Rates were higher than in 1979-82 (table I) and highest in the Northern region (37.1/10 000). This region had the highest proportion of households without cold water taps or lavatories. The percentage of households without baths or hot water was similarly high in each region.

Discussion

We have examined the relation between hospital discharge rates after acute appendicitis and the provision of household amenities and diet in 73 areas within England and Wales, nine of the 15 health board areas in Scotland, and all eight health board areas of Eire. Hospital discharge rates overestimate the incidence of acute appendicitis because a proportion of removed appendices are normal. Recent surveys in Britain and Eire, however, have shown that around 70% of removed appendices show pathological changes and that this proportion does not vary greatly from place to place.⁹ Hence the differences in hospital discharge rates cannot be attributed to differences in surgical practices. We conclude that the distribution of appendicitis is related to the percentage of homes which are without amenities, in particular fixed baths (fig 1) and hot water systems. During the past 20 years comparatively few homes in Britain have been without a cold water tap and lavatory, but data from Scotland in the 1960s (table IV) suggest that there was formerly a relation between appendicitis and these amenities.

In Northern Ireland in 1956, before widespread poliomyelitis vaccination, seropositivity to poliovirus among children was strongly associated with absence of a hot water system in the home.¹⁰ This was independent of social class. It shows the effect of this amenity on the transmission of enteric infections.

In the areas studied lack of baths and hot water systems was strongly related to domestic overcrowding defined as more than 1.5 people per room. Overcrowding is related to respiratory as well as enteric infection. Analyses in three national samples of British children showed that lack of amenities and overcrowding have different relations with appendicitis (see accompanying paper).

The hygiene hypothesis depends on the observation that the response to certain infections is different in early childhood from that in later life. Young children begin to escape infection as improvements in hygiene occur. This renders them vulnerable to appendicitis when they are exposed to infections in later childhood and early adulthood. With continued improvements in hygiene exposure to infections declines and with it appendicitis. The geographical relation between appendicitis and indices of worse hygiene, at a time when the disease is declining, is new evidence in support of the hygiene hypothesis.

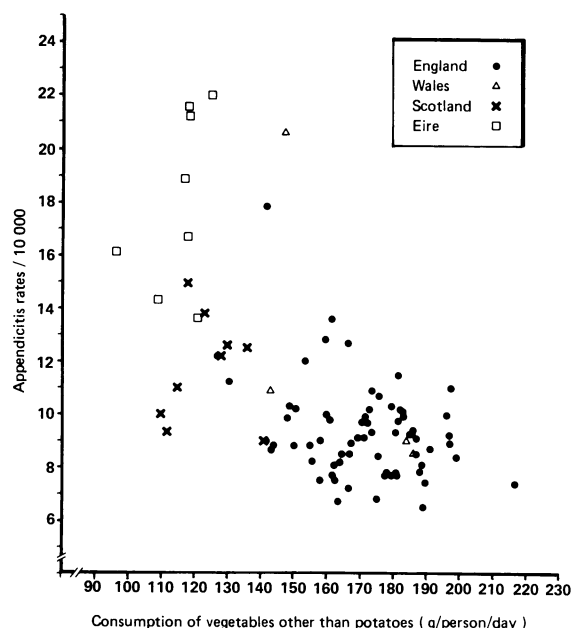


FIG 2—Consumption of vegetables other than potatoes and hospital discharge rates for acute appendicitis in 90 areas of Britain and Eire.

The relation between appendicitis and low consumption of vegetables other than potatoes (fig 2) is independent of the provision of hot water systems and baths (tables II and III). Data on food consumption came from two different sources, the Household Budget Survey in Eire and the National Food Survey in Britain. The first of these is subject to error, as food consumption was estimated from regional household expenditure on food and food prices in Dublin. The large differences between Eire and England, however, are unlikely to be due solely to inaccuracies, and the dietary correlations in the 90 areas studied were consistent with findings in an earlier study within England and Wales.³ In that study we suggested that the association with potatoes reflected the inverse relation between their consumption and that of other vegetables, in particular green vegetables and tomatoes, which may protect against appendicitis. This may be through an effect on the substrate of the bacterial flora of the appendix, whose invasion of the distal appendicular wall is the ultimate event in pathogenesis.

We conclude that geographical differences in incidence of appendicitis in Britain and Eire are related to differences in hygiene. Changes in hygiene have determined the time trends of the disease. Consumption of green vegetables is an additional influence on the geographical distribution.

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